AMENDMENTS TO THE SPECIFICATION:

Please amend the specification as follows:

On page 1, after the title, please add the following paragraph:

This application is a national stage filing under 35 U.S.C. § 371 of International Application No. PCT/EP2004/0008103, filed on July 20, 2004, which published in the English language and claims the benefit of priority to European Application No. 03018101.0, filed August 8, 2003.

On page 1, please replace the paragraph beginning at line 7 with the following:

The present invention generally relates to the field of data processing~~,~~. ~~and more~~ More particularly and without limitation, the invention relates to methods and systems related to object size balancing in a multi-computing environment.

On page 1, please replace the title beginning at line 9 with the following:

Background ~~and prior art~~

On page 1, please replace the paragraph beginning at line 10 with the following:

Various multi-computing architectures are known ~~from the prior art~~ where a plurality of processing units ~~is~~ are coupled to form a cluster. Such architectures are used in parallel processing and also in the emerging field of blade computing.

On page 1, please replace the paragraph beginning at line 13 with the following:

Blade computing relies on blade servers, which are modular, single-board computers. An overview of blade computing is given in "Architectures and Infrastructure for Blade Computing", September 2002, Sun ~~microsystems~~ Microsystems and "THE

NEXT WAVE: BLADE SERVER COMPUTING", Sun Microsystems (www.sun.com/servers/entry/blade).

On page 1, please replace the paragraph beginning at line 17 with the following:

A content load balancing blade is commercially available from Sun ~~microsystems~~ Microsystems, for example, the ~~("~~Sun Fire TM B10n~~)~~. This blade provides traffic and content management functionalities. Content load balancing is achieved based on URLs, CGI scripts and ~~cookies; server~~ cookies. Server load balancing is achieved based on server loads, response times, and weighted round-robin algorithms.

On page 2, please replace the paragraph beginning at line 8 with the following:

~~The~~ Methods and systems consistent with the present invention ~~provides~~ are provided for a method of assigning objects to processing units of a cluster of processing units. Each one of the processing units has a certain storage capacity. For the purpose of balancing the sizes of objects of the individual processing units, a given number of objects needs to be distributed. This is accomplished by sorting of the objects by size, which provides a sequence of objects. This sequence is used for assigning of objects to processing units.

On page 2, please replace the paragraph beginning at line 14 with the following:

~~The~~ In accordance with one embodiment of the invention, the procedure for assigning of objects to a processing unit~~,~~ starts with the largest object of the sequence and continues until the remaining storage capacity of the processing unit is below the size of the smallest remaining object of the sequence. When this condition is fulfilled, the procedure is carried out again for the next processing unit, whereby the objects

which have been previously assigned, are deleted from the sequence. This way a minimum number of processing units, which are required for handling a given set of objects, can be determined.

On page 2, please replace the paragraph beginning at line 21 with the following:

In accordance with ~~a preferred~~ another embodiment of the invention, each processing unit is a single-board computer that has a bus interface to a bus system that couples a plurality of the single-board computers. Each of the single-board computers ~~has its~~ may include private processing and data storage resources. Data processing tasks or sub-tasks of a complex data processing task are assigned to the single-board computers by a control unit. The control unit can be a separate hardware unit or a software process that runs on one of the single-board computers. An example of such a distributed data processing system is a cluster of blades.

On page 3, please replace the paragraph beginning at line 1 with the following:

In accordance with ~~a preferred~~ another embodiment of the invention, the remaining storage capacity of a processing unit is determined by the difference between the storage capacity of the unit and the aggregated size of objects, which have been assigned to the processing unit. On the basis of this definition of the remaining storage capacity, the minimum number of processing units is determined.

On page 3, please replace the paragraph beginning at line 6 with the following:

In accordance with a further ~~preferred~~ embodiment of the invention, the object size balancing procedure is performed again in order to further improve the object size balancing. For this purpose, the largest gap between the aggregated sizes of objects

~~being~~ assigned to one of the processing units and the maximum storage capacity is determined.

On page 3, please replace the paragraph beginning at line 17 with the following:

In accordance with a further ~~preferred~~ embodiment of the invention, the theoretical storage capacity limit for a perfectly evenly distributed load is used as a threshold. This threshold is obtained by calculating the difference between the total of the storage capacities of the processing units and the total of the sizes of the objects and dividing the difference by the minimum number of processing units. The result of the division is subtracted from the storage capacity, which provides the theoretical limit.

On page 3, please replace the paragraph beginning at line 28 with the following:

In this case one ~~ore~~ or more iterations are performed. For one iteration the excess amount of memory is divided by the minimum number of processing units. The result of the division is added to the threshold and the assignment procedure is performed again. This process continues until the storage capacity of the last processing unit, to which the remaining objects of the sequence are assigned in the procedure, is sufficient to accommodate all these objects. This way, the object size balancing ~~is~~ may be further improved.

On page 4, please replace the paragraph beginning at line 4 with the following:

In accordance with a further ~~preferred~~ embodiment of the invention, the threshold for performing the assignment procedure is varied between the theoretical limit and the storage capacity. For each value of the threshold, a new assignment procedure is performed. For each of the assignments of objects to processing units, a statistical

measure is calculated. This statistical measure is a basis to select one of the assignments for optimal object size balancing.

On page 4, please replace the paragraph beginning at line 10 with the following:

In accordance with a further ~~preferred~~ embodiment of the invention the standard deviation or variance of the sum of the object sizes assigned to a processing unit is used as a statistical measure. The standard deviations obtained for the processing units as a result of the assignment procedure are stored as an overall quality measure of the assignment. The assignment having the lowest overall quality measure is selected.

On page 4, please replace the paragraph beginning at line 15 with the following:

In accordance with a further ~~preferred~~ embodiment of the invention, each one of the processing units is a blade or a blade server. One of the blades can have a program, which implements the principles of the present invention, in order to perform object size balancing. This way, the number of swap-operations between the blades can be minimized.

On page 4, please replace the paragraph beginning at line 20 with the following:

In accordance with a further ~~preferred~~ embodiment of the invention the principles of the invention are implemented in an application program running on a personal computer. The application program is provided with a list of objects and the estimated sizes of the objects, which needs to be handled by the cluster of processing units. On the basis of the object sizes, the minimum number of processing units which are

required for the processing can be determined. This information can form the basis for a corresponding investment decision of a customer.

On page 5, please replace the paragraph beginning at line 6 with the following:

Figure 1 is a schematic block diagram of an exemplary modular computer system, having a cluster of blades, consistent with an embodiment of the present invention;

On page 5, please replace the paragraph beginning at line 8 with the following:

Figure 2 is ~~illustrative of~~ a flow diagram for an exemplary method for assigning of objects to blades and for determining the minimum number of blades, consistent with an embodiment of the present invention;

On page 5, please replace the paragraph beginning at line 10 with the following:

Figure 3 is an example ~~for~~ of tables, which need to be assigned to blades, consistent with an embodiment of the present invention;

On page 5, please replace the paragraph beginning at line 11 with the following:

Figure 4 ~~shows~~ illustrates the result of ~~a~~ an exemplary sorting operation, consistent with an embodiment of the present invention;

On page 5, please replace the paragraph beginning at line 12 with the following:

Figure 5 ~~shows a~~ illustrates an exemplary first step of assigning a table to a first one of the blades, consistent with an embodiment of the present invention;

On page 5, please replace the paragraph beginning at line 13 with the following:

Figure 6 ~~shows a~~ illustrates an exemplary second step for assigning a table to the first blade, consistent with an embodiment of the present invention;

On page 5, please replace the paragraph beginning at line 14 with the following:

Figure 7 shows the first assignment of a table to a second blade, consistent with an embodiment of the present invention;

On page 5, please replace the paragraph beginning at line 15 with the following:

Figure 8 shows a second assignment of a table to the second blade, consistent with an embodiment of the present invention;

On page 5, please replace the paragraph beginning at line 16 with the following:

Figure 9 shows the assignment of three further tables to the second blade, consistent with an embodiment of the present invention;

On page 5, please replace the paragraph beginning at line 17 with the following:

Figure 10 shows the resulting assignment of tables to blades as a result of the assignment procedure, consistent with an embodiment of the present invention;

On page 5, please replace the paragraph beginning at line 19 with the following:

Figure 11 ~~is illustrative of a preferred embodiment of the invention ,~~ illustrates an example where the procedure of ~~figure~~ Figure 2 is performed again with a lower threshold, consistent with an embodiment of the present invention;

On page 5, please replace the paragraph beginning at line 21 with the following:

Figure 12 ~~is illustrative of~~ illustrates the lower threshold, consistent with an embodiment of the present invention;

On page 6, please replace the paragraph beginning at line 1 with the following:

Figure 13 ~~is illustrative of~~ illustrates the result of the renewed performance of the procedure of ~~figure~~ Figure 2 with the lower threshold, consistent with an embodiment of the present invention;

On page 6, please replace the paragraph beginning at line 3 with the following:

Figure 14 ~~is illustrative of a preferred embodiment of a~~ illustrates an exemplary method of the invention where the threshold is varied iteratively, consistent with an embodiment of the present invention;

On page 6, please replace the paragraph beginning at line 5 with the following:

Figure 15 ~~is illustrative of~~ illustrates the starting point of the iteration, consistent with an embodiment of the present invention;

On page 6, please replace the paragraph beginning at line 6 with the following:

Figure 16 ~~shows~~ illustrates the result of the first iteration, consistent with an embodiment of the present invention;

On page 6, please replace the paragraph beginning at line 7 with the following:

Figure 17 ~~shows~~ illustrates the resulting assignment of objects to the minimum number of blades after completion of the procedure of ~~figure~~ Figure 14, consistent with an embodiment of the present invention;

On page 6, please replace the paragraph beginning at line 9 with the following:

Figure 18 ~~is illustrative of~~ illustrates a further ~~preferred embodiment of the invention,~~ example where the threshold is varied in predetermined steps, consistent with an embodiment of the present invention;

On page 6, please replace the paragraph beginning at line 11 with the following:

Figure 19 ~~is illustrative of~~ illustrates the discrete continuum in which the threshold is varied and the result of the assignment procedure, consistent with an embodiment of the present invention; and

On page 6, please replace the paragraph beginning at line 13 with the following:

Figure 20 ~~is illustrative of a~~ illustrates an exemplary computer system performing the assignment of objects to blades.

On page 6, please replace the paragraph beginning at line 16 with the following:

Figure 1 is a schematic block diagram of an exemplary modular computer system, having a cluster of blades, consistent with an embodiment of the present invention. Figure 1 shows cluster 100 of blades B_1, B_2, B_3, ..., B_N. Each one of the blades has processor 102 and memory 104. In the example considered here, all memories 104 have the same storage capacity. The blades are coupled by a network 106, such as a bus system. The number N of blades of cluster 100 needs to be chosen, such that a given number of M objects of varying sizes can be handled.

On page 6, please replace the paragraph beginning at line 21 with the following:

For example, cluster 100 implements a ~~so-called~~ search engine. In this instance, identical search processors run on each one of the blades. The assignment of data

objects, such as index tables~~,~~ to blades, can be stored in a dispatcher unit (not shown in the drawing) of cluster 100. ~~This way~~ As a result, data objects are assigned to blades and data processing tasks running on the blades.

On page 7, please replace the paragraph beginning at line 4 with the following:

Figure 2 is a flow diagram for an exemplary method of assigning of objects to blades and for determining the minimum number of blades, consistent with an embodiment of the present invention. Figure 2 shows the corresponding procedure for assigning the objects to blades and thereby determine the minimum value for N.

On page 7, please replace the paragraph beginning at line 6 with the following:

In step 200, a sorting operation is performed in order to sort the M objects by size. The corresponding object sequence is provided in step 202. In step 204 the index i for the blades is ~~initialised~~ initialized to one.

On page 8, please replace the paragraph beginning at line 3 with the following:

Figure 3 ~~shows an example~~ is an example of tables, which need to be assigned to blades, consistent with an embodiment of the present invention. In the example considered here, the objects are a number of twenty different tables having various sizes between 50 MB and 3566 MB as indicated in ~~figure~~ Figure 3. For example, table 1 has a size of 3250 MB, table 2 has 250 MB, table 3 has 750 MB, etc. The table sizes can be actual table sizes or average table sizes which have been obtained by monitoring a real life data processing system. Alternatively, the table sizes are estimates for the purpose of planning cluster 100.

On page 8, please replace the paragraph beginning at line 9 with the following:

Figure 4 shows the result of the sorting operation performed on the tables 1 to 20 of ~~figure~~ Figure 3 (cf. step 202 of ~~figure~~ Figure 2), consistent with an embodiment of the present invention.

On page 8, please replace the paragraph beginning at line 11 with the following:

Figure 5 illustrates the assignment of the first object of the sequence, i.e., the largest table 20 to blade B_1, consistent with an embodiment of the present invention. In the example considered here, each blade has a storage capacity of 4 GB = 4096 MB of main memory. Table 20 has a size of 2566 MB, which leaves a gap G of 530 MB of remaining storage capacity (cf. step 210 of ~~figure~~ Figure 2).

On page 8, please replace the paragraph beginning at line 15 with the following:

~~Next it~~ It is then determined whether there is a next object in the sequence which fits into the gap G. Table 12, which has a size of 520 MB, is the largest table which fits into the gap G. This table 12 is thus also assigned to blade 1. The aggregated size of the objects assigned to blade 1, i.e., table 20 and table 12, is 4068 MB, which leaves a gap G of 10 MB. This gap G of 10 MB is too small to accommodate even the smallest remaining object of the sequence of tables.

On page 8, please replace the paragraph beginning at line 21 with the following:

~~As there remain~~ Because tables remain in the sequence which have not yet been assigned to a blade, the index i is incremented and the assignment procedure goes to the next blade B_2 (cf. steps 218 and 220 of ~~figure~~ Figure 2). With respect to blade B_2

the above-explained procedure is carried out again on the basis of the unassigned tables, which remain in the sequence.

On page 8, please replace the paragraph beginning at line 26 with the following:

~~This way~~ As a result, the largest remaining table of the sequence, i.e., table 15, is assigned to blade B_2 which leaves a gap G of 596 MB. The gap G is filled with tables 6, 2, 13 and 14 as illustrated in ~~figures~~ Figures 7 and 8. The resulting assignment of tables to blade B_2 is shown in ~~figure~~ Figure 9.

On page 9, please replace the paragraph beginning at line 1 with the following:

The aggregated size of the tables, which have been assigned to blade B2, i.e., tables 15, 6, 2, 13 and 14, leave a gap G of 76 MB which is not enough to accommodate the smallest unassigned table, i.e., table 11, of the sequence. Thus, the index i is incremented and the assignment procedure is continued for the next blade B_3. This process goes on until all tables of the sequence have been assigned to one blade B_i. The result of the assignments of tables to blades is illustrated in ~~figure~~ Figure 10.

On page 9, please replace the paragraph beginning at line 7 with the following:

In addition to the assignment of tables to blades, ~~this way~~ the minimum number N of blades, which are required for handling of the given number of tables (cf. ~~figure~~ Figure 3), is also obtained. In the example considered here, the resulting assignment of tables to the N = 8 blades leaves a gap G of 2196 MB on blade 8. In order to further improve the object size balancing the method of ~~figure~~ Figure 11 is carried out.

On page 9, please replace the paragraph beginning at line 12 with the following:

In step 1100 the largest gap G is determined. In the example shown in ~~figure~~ Figure 10, this is the gap G of blade B_8. The other blades B_1 to B_7 have smaller gaps between the aggregated size of the tables assigned to the corresponding blade and the storage capacity of 4 GB.

On page 9, please replace the paragraph beginning at line 16 with the following:

In step 1102 the gap G determined in step 1100 is divided by the number N of blades. In the example of ~~figure~~ Figure 10, this means that G = 2196 MB is divided by N = 8 in order to obtain the value of Delta 1 = 275 MB. In step 1104 a threshold is calculated by subtracting Delta 1 from the storage capacity, i.e., threshold = 4096 MB - 275 MB = 3821 MB.

On page 9, please replace the paragraph beginning at line 20 with the following:

With the threshold calculated in step 1104, the method of ~~figure~~ Figure 2 is performed again in step 1106. The resulting assignment of the objects to the blades is more evenly distributed due to the lowering of the threshold. This is illustrated by way of example in ~~figures~~ Figures 12 and 13 for the example of ~~figure~~ Figure 10.

On page 9, please replace the paragraph beginning at line 24 with the following:

Figure 12 shows the threshold T, which has been calculated in step 1104, consistent with an embodiment of the present invention. With the lowered threshold T, the assignment procedure of ~~figure~~ Figure 2 is restarted from the beginning whereby steps 200 and 202 do not need to be performed again, if the sorted object sequence has been stored when the procedure of ~~figure~~ Figure 2 was carried out the first time.

On page 10, please replace the paragraph beginning at line 1 with the following:

The resulting assignment of database tables to blades after the renewed performance of the procedure of ~~figure~~ Figure 2 with the lowered threshold T is shown in ~~figure~~ Figure 13. As apparent from the comparison of ~~figures~~ Figures 10 and 13 the load is more evenly balanced between the blades after the renewed assignment procedure.

On page 10, please replace the paragraph beginning at line 13 with the following:

In step 1404 the method of ~~figure~~ Figure 2 is performed again with the threshold as determined in step 1402 whereby the number N is fixed, i.e., for the last blade B_N which is processed. In one embodiment, the storage capacity will not be sufficient in most cases. In the resulting assignment of objects to blades, it is checked whether for the last blade, which has been processed, there is in fact an excess amount of memory requirement, which exceeds the storage capacity.

On page 10, please replace the paragraph beginning at line 25 with the following:

Figure 15 is based on the example of ~~figure~~ Figure 10 and shows the threshold T as calculated in accordance with step 1402 of ~~figure~~ Figure 14. In the example considered here, the difference between the sum of the storage capacities of the blades and the sum of the table sizes is 3 GB. The 3 GB are evenly distributed over the 8 blades, which provides the threshold T.

On page 11, please replace the paragraph beginning at line 11 with the following:

Figure 16 shows the result of the assignment procedure of ~~figure~~ Figure 2, which has been performed with the threshold T as determined in step 1402, consistent with an

embodiment of the present invention. As a result of the assignment procedure, there is an excess amount of memory E for blade B_8. In the example considered here, the excess memory amount E is 858 MB. In accordance with step 1410 the excess amount E is divided by the number of blades N = 8. In accordance with step 1412 the resulting amount of memory Delta 3 = 107 MB is added to the threshold. Next the assignment method of ~~figure~~ Figure 2 is carried out again with the increased threshold, which provides the result as shown in ~~figure~~ Figure 17.

On page 11, please replace the paragraph beginning at line 19 with the following:

Figure 18 shows a further alternative for refinement of the object size balancing, consistent with an embodiment of the present invention. First the step 1400 of the method of ~~figure~~ Figure 14 is carried out in order to calculate Delta 2. Delta 2 is equivalent to the gap between the theoretical limit, i.e., the threshold as calculated in step 1402 of the method of ~~figure~~ Figure 14, and the storage capacity of a blade.

On page 11, please replace the paragraph beginning at line 26 with the following:

In step 1800 Delta 2 is divided by the number of increments, which provides Delta 4. In step 1802 the threshold is calculated by dividing the sum of the object sizes by the number of blades N. With this threshold the assignment method of ~~figure~~ Figure 2 is performed again in step 1804.

On page 12, please replace the paragraph beginning at line 13 with the following:

Figure 19 illustrates this method with respect to the example shown in ~~figure~~ Figure 10, consistent with an embodiment of the present invention. The threshold T of 3712 MB is obtained by the calculation of step 1802. From there the threshold is

stepwise increased in increments of Delta 4, which is Delta 2 = 384 MB divided ~~my~~ by the number of increments. For example, the number of increments is 100. For each assignment procedure the standard deviation of the table sizes assigned to blades is calculated for selection of one of the assignments. ~~Preferably the~~ The standard deviations are preferably calculated only for those assignments which fit onto the minimum number of blades.

On page 13, please replace the paragraph beginning at line 1 with the following:

In operation, the table with the object names/numbers and object sizes is entered via interface 124 and stored in storage 118. This corresponds to the information shown in ~~figure~~ Figure 3.

On page 13, please replace the paragraph beginning at line 7 with the following:

~~Next program~~ Program 112 ~~is~~ may then be invoked. Program 112 sorts the table of storage 118 by size to provide a sequence of objects (cf. ~~figure~~ Figure 4). Next module 116 performs the method of ~~figure~~ Figure 2 in order to determine the minimum number of required blades. This minimum number is stored in storage 122 and is outputted via user interface 124. This number can be a basis for a users investment decision for purchasing the number of blades to realize a data processing system being capable of handling the objects as listed in the table.

On page 13, please replace the paragraph beginning at line 14 with the following:

In addition, module 116 can perform the methods of ~~figure~~ Figure 11, ~~figure~~ Figure 14 and/or ~~figure~~ Figure 18 for refinement of the object size balancing.

Please delete page 14 in its entirety.